COMPACT RADIO SOURCES: THEIR USE AND SIZE

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Compact radio sources are both interesting from an astrophysical point of view and useful for geophysics. They propose some very interesting astrophysical questions as to their energy generation and transport. Their small size allows the measurement of their positions to unprecedented accuracy ($< 0\rlap{.}''01$) extending astrometric measurements of parallax and proper motions to further distances. These celestial "beacons" may be used to establish an almost inertial reference frame against which positions on the earth and the earth's motions such as Universal Time (UT1) and polar motion may be measured to centimeter scale accuracy. Finally these sources when used in conjunction with radio interferometry can allow precise time synchronization over global distances at subnanosecond accuracy.

For the sake of reference, let us define a compact radio source as one which is unresolved at resolutions less than or equal to 3 milliarcseconds (mas) at a radio frequency of 5 GHz. In order to be useful to the geophysicist, these sources should also display a flux density of > 0.5 Jy, allowing measurements to be made with an interferometer utilizing small diameter (< 3 meters) antennas.

In the late sixties, the development of Very Long Baseline Interferometry (VLBI) showed that radio sources exist having components of size scale a mas. The construction of the Very Large Array (VLA) allowed the determination of the spatial structure of a large number of radio sources on the scale of one arc second. In a survey of all 444 extragalactic sources of flux density > 1 Jy between -45° and 70° declination (Ulvestad, Johnston, Perley, and Fomalont 1981) 197 sources have more than 90% of their flux density in components < 1". The typical arc second scale structure displayed by high dynamic range observations is 1) a compact unresolved source with one-sided structure extending several kiloparsecs from the dominant compact source, e.g. 3C345, 2) two-sided asymmetrical structure, again with a dominant compact component, e.g. 4C55.17, or 3) complex structure surrounding a dominant compact source, e.g. 1150+497 (Perley, Fomalont, and Johnston 1981; Browne et al. 1981). There may be a correlation between source intensity and arc second

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structure, with the most intense sources displaying simple one-sided structure or no structure at all.

Extension of studies of detailed source structure to the mas level can only be accomplished by multistation VLBI observations of the strongest (> 1 Jy) sources using the limited bandwidth of the Mark II VLBI recording system. Systematic measurements of a large number of sources have only begun. Measurements of a large number of sources with reasonable dynamic range (Pearson and Readhead 1981; Eckart et al. 1982) demonstrate that on the mas level, sources may be classified again into the same categories as the arc second structure with the exception that there are many more one-sided asymmetric sources.

Measurements at 5 GHz with a synthesized beam of ∿ 1 mas using VLBI networks consisting of five and six U. S. stations and the 100 meter telescope at Effelsberg, FRG, of the 12 S5 sources ($\delta > 70°$) with $S > 1$ Jy have shown these sources to be very compact (Eckart et al. 1982). All the sources have at least 50% of the flux density in compact cores while the five BL Lacertae objects have 70% of their flux density in a compact core of less than 3 mas. The source 0454+844 may be the most compact source known with 95% of its flux density emanating from a core of size < 1 mas. The sizes for many of the compact cores are $\leq 0''.3$ as measured from the visibilities on the longest baselines and have brightness temperatures of $\sim 10^{11}$K. With baselines of size larger than the earth's diameter, probably many compact sources will exceed brightness temperatures of 10^{12}K which is the limit put on the size of inhomogeneous electron synchrotron sources by Compton scattering.

The only explanation for this predicted result is that the source structure and sizes seen on the mas scale are due to relativistic doppler beaming along the line of sight. This is certainly true for the strong S5 sources. An example of a source which displays relativistic jets of particles is SS433 (Hjellming and Johnston 1982). If this galactic source is scaled up from 1 $M_\odot$ to about 10^8 $M_\odot$ and the jet velocity increased to 0.9c, this source may be used to model extragalactic sources.

More maps of higher dynamic range are needed of the mas scale structure in radio sources in order to study in detail the process giving rise to these intense, compact sources. We await the full use of the VLBI technique through improved facilities.

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